

## Lick Creek/Cranes Nest River Hydrologic Calibration/Validation for HSPF

This document presents the Hydrologic Simulation Program Fortran (HSPF) hydrologic calibration/validation for the Lick Creek watershed bacteria TMDL. Because there was no hydrology station on Lick Creek, the detailed calibration was performed for nearby Cranes Nest River, and the results were visually compared to the sparse flow data available for Lick Creek. The time-step used in the hydrologic simulations was 1 hour. Observed daily flow data for Cranes Nest River were available from the USGS monitoring station 03208950, Cranes Nest River near Clintwood, VA. Daily flow data were used in the hydrologic calibration/validation. Meteorological data were obtained primarily from the National Weather Service COOP station Wise 3E (449215). Wise 3E is located at the southern tip of the Cranes Nest River watershed. The results presented in this document follow the guidance suggested by DEQ.

### Hydrologic Calibration and Validation

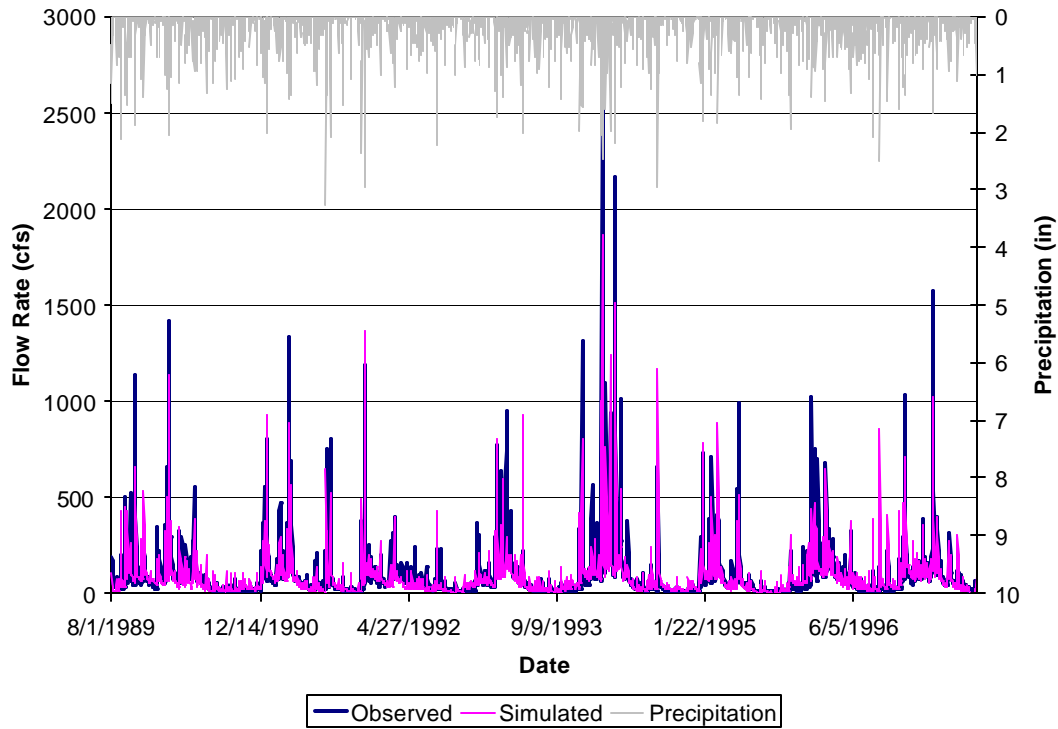
The hydrologic calibration period was August 1, 1989 to July 31, 1997. The hydrologic validation period was from May 1, 2001 to July 31, 2005. The output from the HSPF model for both calibration and validation was daily average flow in cubic feet per second (cfs). Calibration parameters were adjusted within the recommended range.

The HSPEXP decision support system developed by USGS was used to calibrate the hydrologic portion of HSPF for Cranes Nest River. The default HSPEXP criteria for evaluating the accuracy of the flow simulation were used in the calibration for Cranes Nest River. These criteria are listed in Table 1. After calibration, all criteria listed in Table 1 were met.

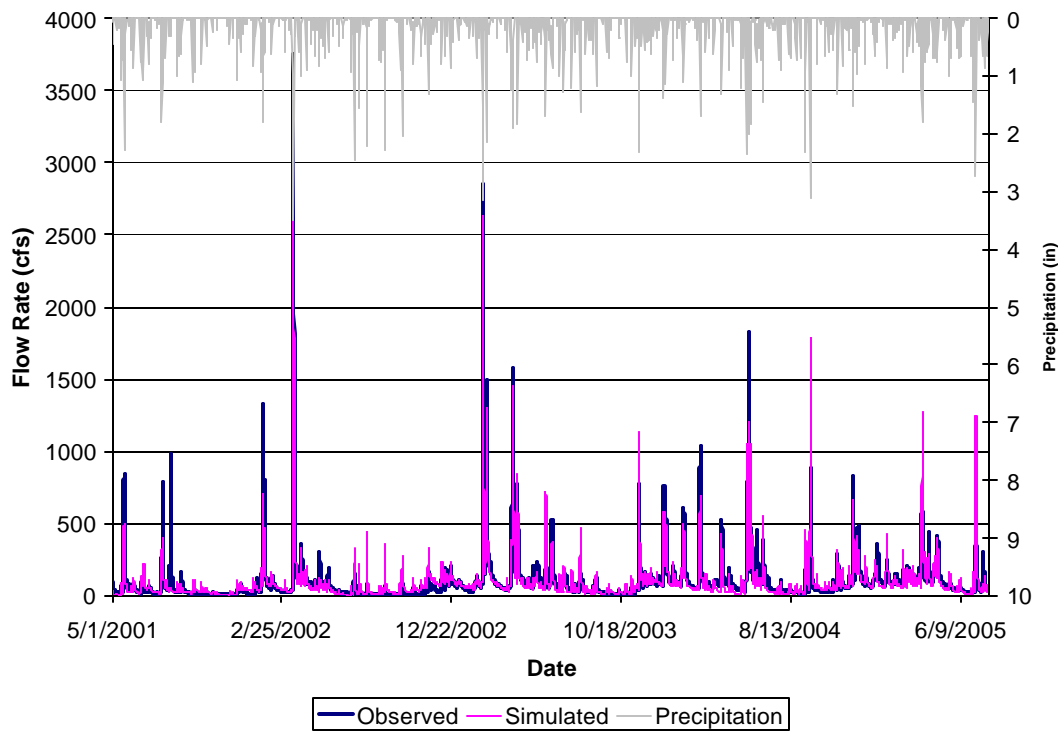
**Table 1. Default criteria for HSPEXP.**

Variable	Percent Error
Total Volume	10%
50 % Lowest Flows	10%
10 % Highest Flows	15%
Storm Peaks	15%
Seasonal Volume Error	10%
Summer Storm Volume Error	15%

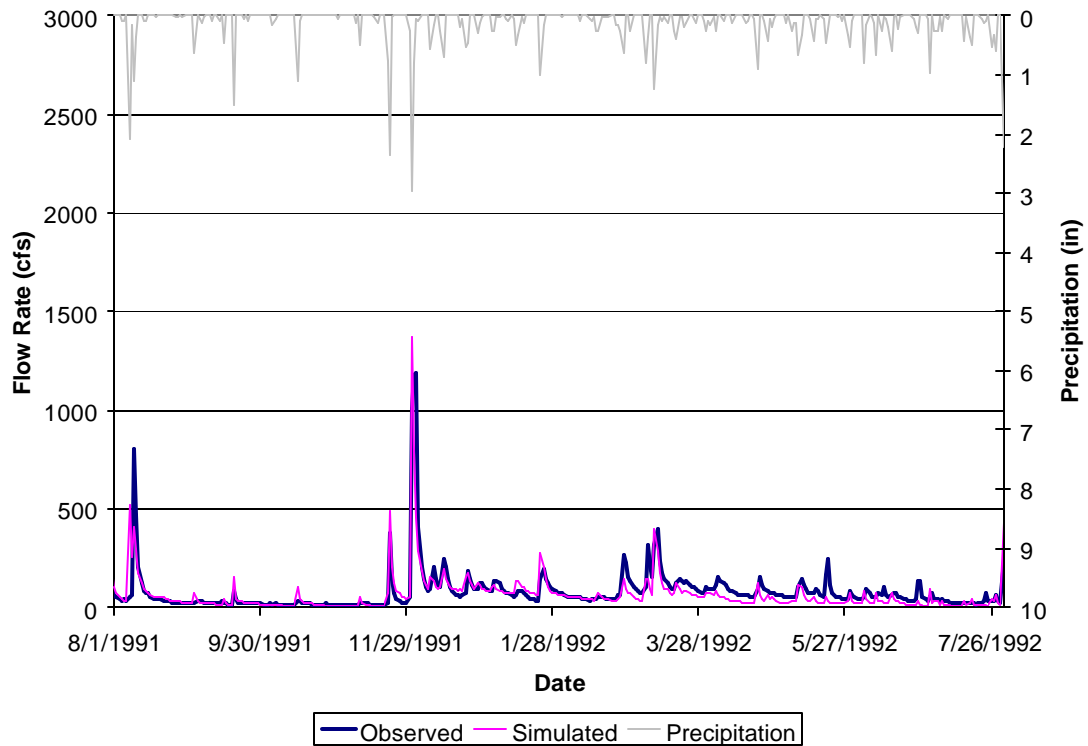
The simulated flow for both the calibration and validation matched the observed flow well, as shown in Figures 1 and 2. The agreement with observed flows is further illustrated in Figures 3 and 4 for a representative year and Figures 5 and 6 for a representative storm. Daily precipitation data from the Wise 3E station was disaggregated to hourly values using the routine embedded in the WDMUtil program for use in this simulation.



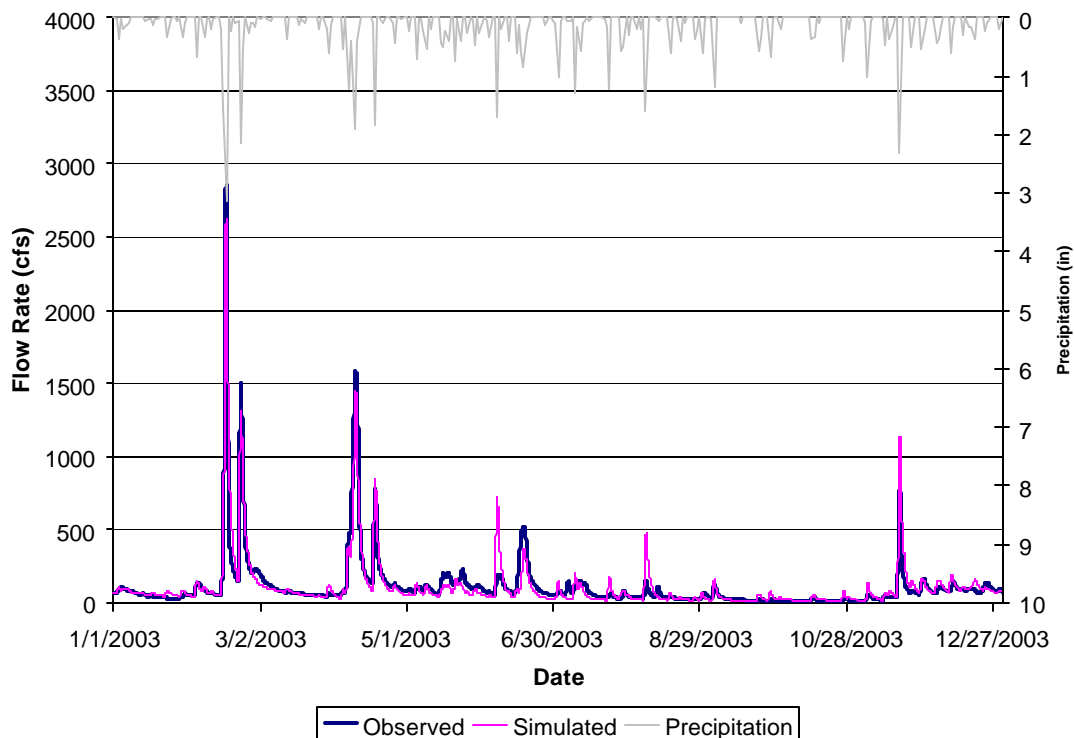
**Figure 1. Observed and simulated flows and precipitation for Cranes Nest River for the calibration period.**



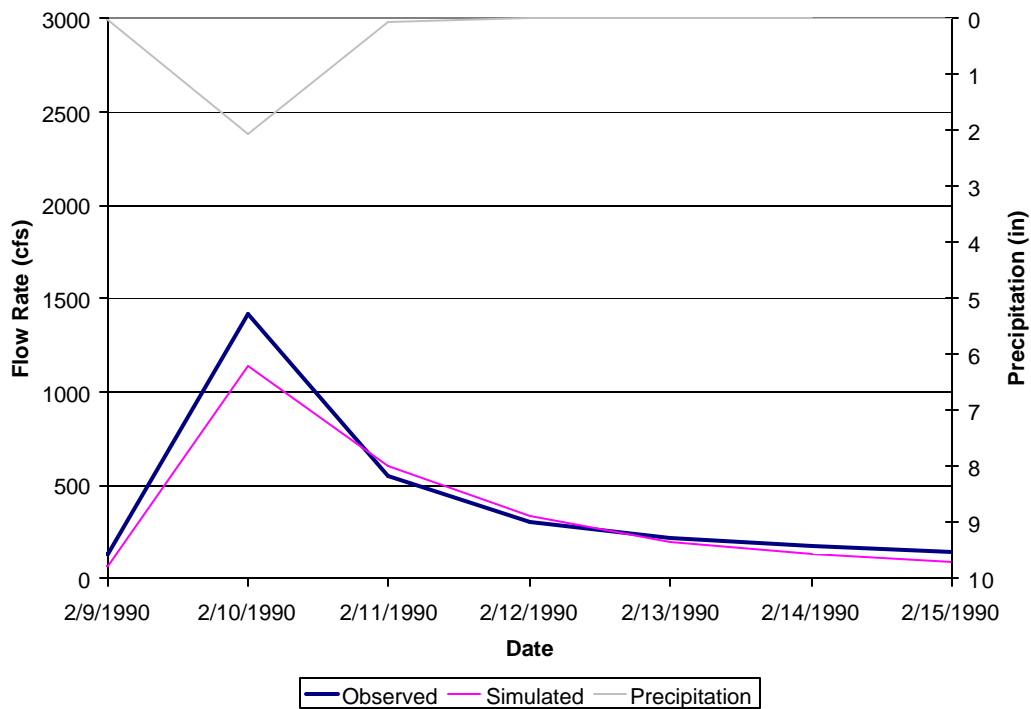
**Figure 2. Observed and simulated flows and precipitation for Cranes Nest River during the validation period.**



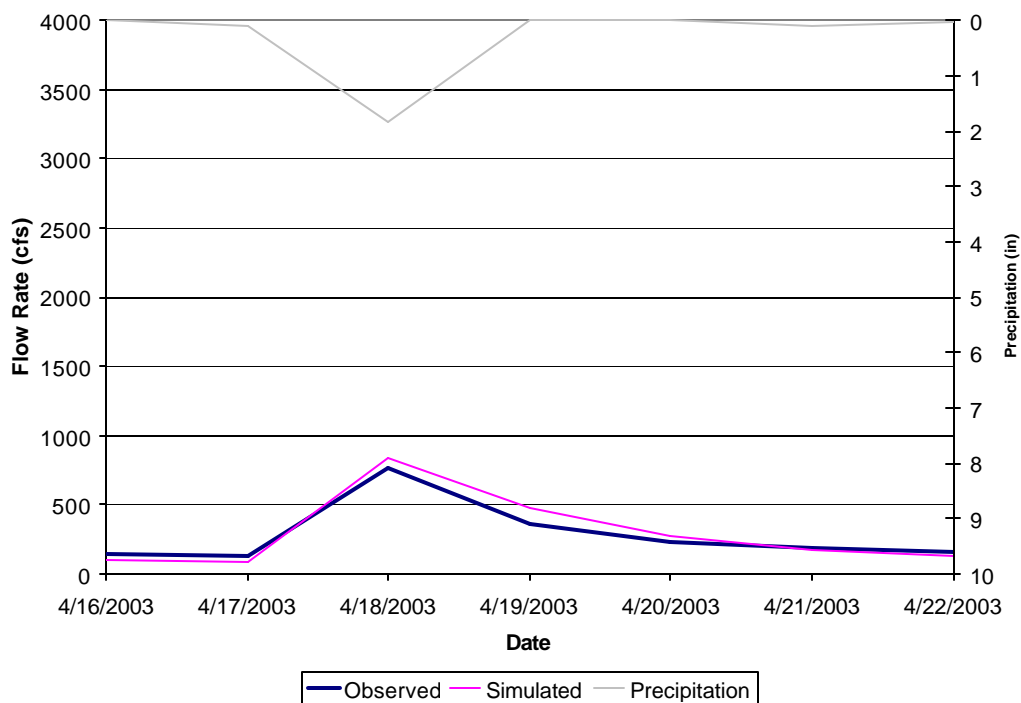
**Figure 3. Observed and simulated flows and precipitation for a representative year in the calibration period for Cranes Nest River.**



**Figure 4. Observed and simulated flows and precipitation for Cranes Nest River during a representative year in the validation period.**

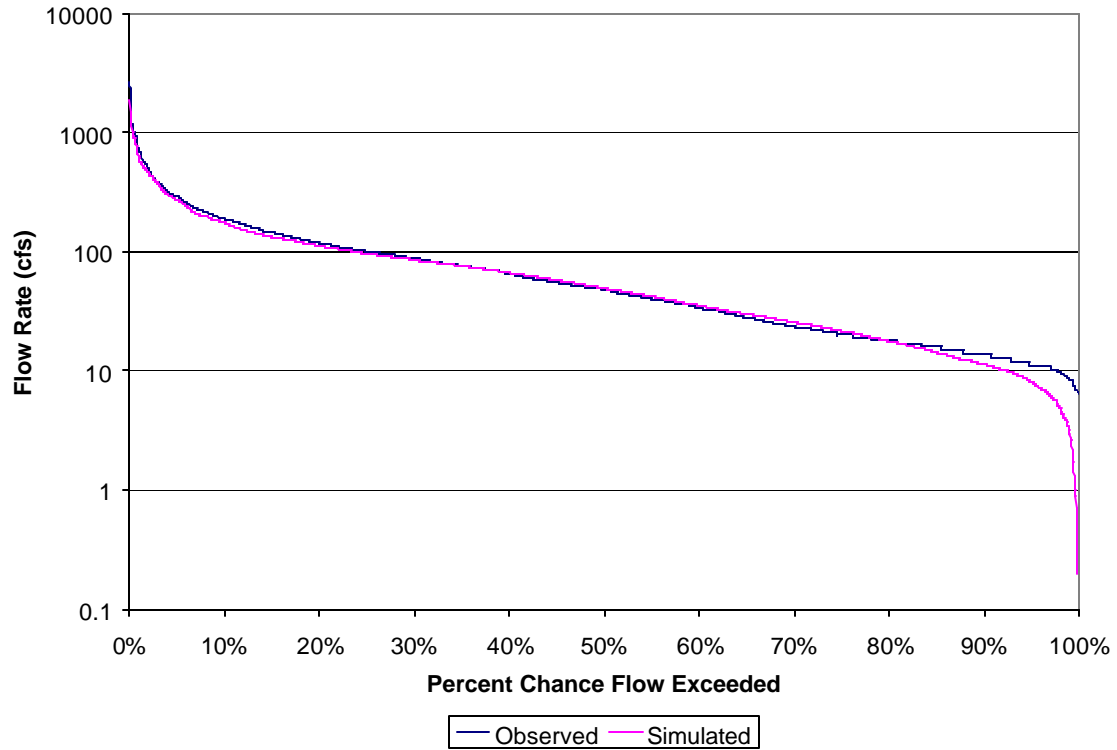


**Figure 5. Observed and simulated flows and precipitation for Cranes Nest River for a representative storm in the calibration period.**

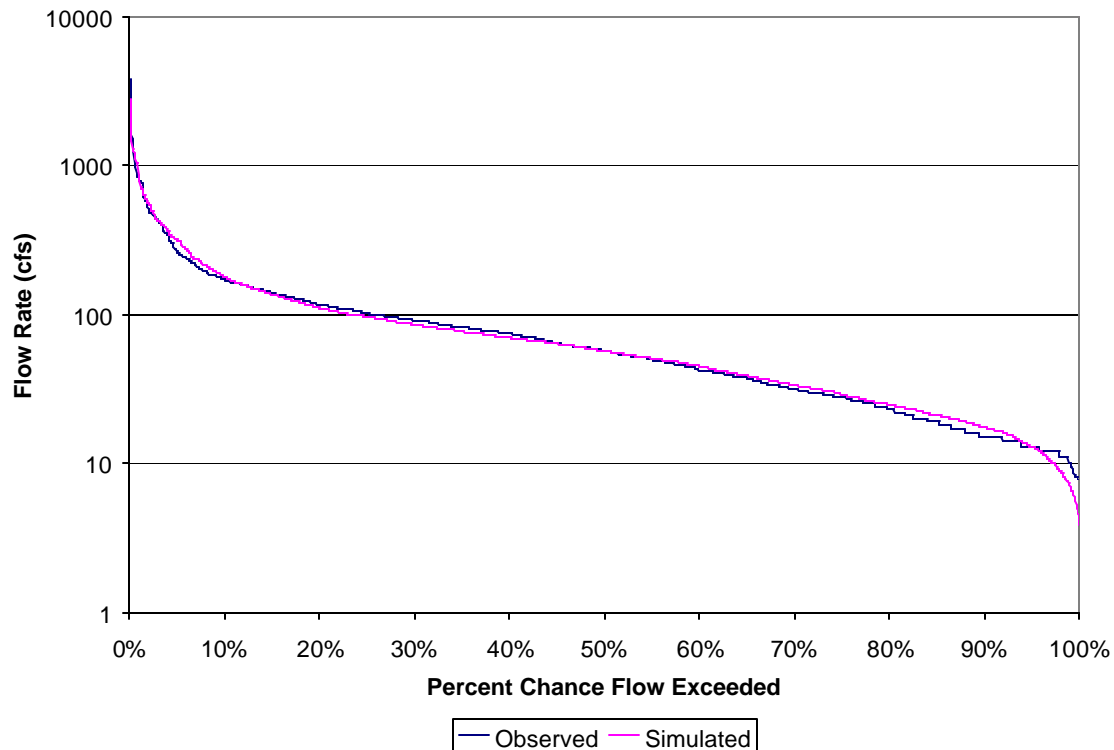


**Figure 6. Observed and simulated flows, and precipitation for Cranes Nest River for a representative storm in the validation period.**

The agreement between the simulated and observed time series can be further seen through the comparison of their cumulative frequency curves (Figures 7 and 8).



**Figure 7. Cumulative frequency curves for the calibration period for Cranes Nest River.**



**Figure 8. Cumulative frequency curves for the validation period for Cranes Nest River.**

The expert system HSPEXP was used to assist with calibrating and validating the Cranes Nest River hydrologic model. Selected diagnostic output from the program is listed in tables 2 and 3. The total winter runoff and total summer runoff errors are considered in the HSPEXP term 'seasonal volume error' (see Table 1). The errors for seasonal volume error were 1.9% for the calibration period and 3.0% for the validation period; both are within the required range of  $\pm 10\%$ .

**Table 2. Summary statistics for the calibration period for Cranes Nest River.**

	Simulated	Observed	Error (%)	Criterion
Total Runoff (in) <sup>†</sup>	136.300	144.625	-5.8	10%
Average Annual Total Runoff (in)	17.038	18.078	-5.8	10%
Total of Highest 10% of flows (in) <sup>†</sup>	57.33	63.42	-9.6	15%
Total of Lowest 50% of flows (in) <sup>†</sup>	18.91	18.97	-0.3	10%
Total Winter Runoff (in) <sup>†</sup>	51.570	54.304	-5.0	na
Total Summer Runoff (in) <sup>†</sup>	15.470	15.973	-3.1	na
Coefficient of Determination, $r^2$	0.73			

<sup>†</sup>total for the 8-year calibration period

na = not applicable; these are not criteria directly considered by HSPEXP

**Table 3. Summary statistics for the validation period for Cranes Nest River.**

	Simulated	Observed	Error (%)	Criterion
Total Runoff (in) <sup>†</sup>	83.680	82.995	+0.8	10%
Average Annual Total Runoff (in)	19.689	19.528	+0.8	10%
Total of Highest 10% of flows (in) <sup>†</sup>	37.820	36.509	+3.6	15%
Total of Lowest 50% of flows (in) <sup>†</sup>	13.230	12.634	+4.7	10%
Total Winter Runoff (in) <sup>†</sup>	25.930	26.000	-0.3	na
Total Summer Runoff (in) <sup>†</sup>	16.590	16.157	+2.7	na
Coefficient of Determination, r <sup>2</sup>	0.76			

<sup>†</sup>total for the 4.25-year calibration period

na = not applicable; these were not criteria directly considered by HSPEXP

Flow partitioning for the Cranes Nest River hydrologic model calibration and validation is shown in Table 4. When the observed flow data were evaluated using HYSEP, the average baseflow indices for the calibration and validation periods were 0.55 and 0.53, respectively. The annual baseflow indices ranged from 0.42 to 0.62 for the calibration period and from 0.42 to 0.60 for the validation period. The baseflow indices for the simulated data are presented in Table 4. The simulated baseflow index is close to the observed index for both periods, and both simulated baseflow indices fall within the observed range of baseflow indices.

**Table 4. Flow partitioning for the calibration and validation periods for Cranes Nest River.**

Average Annual Flow	Calibration	Validation
Total Annual Runoff (in)	17.038	19.689
Surface Runoff (in)	3.171 (19%)	4.169 (21%)
Interflow (in)	4.916 (29%)	6.454 (33%)
Baseflow (in)	8.951 (53%)	9.066 (46%)
Baseflow Index	0.53	0.46

The final calibrated hydrology parameters can be found in Table 5. Following Table 5, a comparison with Lick Creek data is conducted.

**Table 5. Final calibrated parameters for Cranes Nest River.**

Parameter	Definition	Units	FINAL CALIBRATION	FUNCTION OF...	Appendix Table (if applicable)
PERLND					
PWAT-PARM2					
FOREST	Fraction forest cover	none	1.0 forest, 0.0 other	Forest cover	
LZSN	Lower zone nominal soil moisture storage	inches	4.0	Soil properties	
INFILT	Index to infiltration capacity	in/hr	0.186-0.286 <sup>a</sup>	Soil and cover conditions	7
LSUR	Length of overland flow	feet	50-199 <sup>a</sup>	Topography	7
SLSUR	Slope of overland flowplane	none	0.15-0.3111 <sup>a</sup>	Topography	7
KVARY	Groundwater recession variable	1/in	0.0	Calibrate	
AGWRC	Base groundwater recession	none	0.965	Calibrate	
PWAT-PARM3					
PETMAX	Temp below which ET is reduced	deg. F	40	Climate, vegetation	
PETMIN	Temp below which ET is set to zero	deg. F	35	Climate, vegetation	
INFEXP	Exponent in infiltration equation	none	2	Soil properties	
INFILD	Ratio of max/mean infiltration capacities	none	2	Soil properties	
DEEPFR	Fraction of GW inflow to deep recharge	none	0.40	Geology	
BASETP	Fraction of remaining ET from baseflow	none	0.12	Riparian vegetation	
AGWETP	Fraction of remaining ET from active GW	none	0.10	Marsh/wetlands ET	
PWAT-PARM4					
CEPSC	Interception storage capacity	inches	monthly <sup>b</sup>	Vegetation	8
UZSN	Upper zone nominal soil moisture storage	inches	0.8	Soil properties	
NSUR	Mannings' n (roughness)	none	0.37 forest and pasture; 0.27 crop; 0.10 LDR and Extractive; 0.05 HDR	Land use, surface condition	
INTFW	Interflow/surface runoff partition parameter	none	1.5	Soils, topography, land use	
IRC	Interflow recession parameter	none	0.5	Soils, topography, land use	
LZETP	Lower zone ET parameter	none	monthly <sup>b</sup>	Vegetation	9

**Table 5. Final calibrated parameters for Cranes Nest River.**

Parameter	Definition	Units	FINAL CALIBRATION	FUNCTION OF...	Appendix Table (if applicable)
IMPLND					
IWAT-PARM2					
LSUR	Length of overland flow	feet	116	Topography	
SLSUR	Slope of overland flowplane	none	0.22	Topography	
NSUR	Mannings' n (roughness)	none	0.08	Land use, surface condition	
RETSC	Retention/interception storage capacity	inches	0.100	Land use, surface condition	
IWAT-PARM3					
PETMAX	Temp below which ET is reduced	deg. F	40	Climate, vegetation	
PETMIN	Temp below which ET is set to zero	deg. F	35	Climate, vegetation	
RCHRES					
HYDR-PARM2					
KS	Weighting factor for hydraulic routing		0.5		

<sup>a</sup>Varies with land use<sup>b</sup>Varies by month and with land use

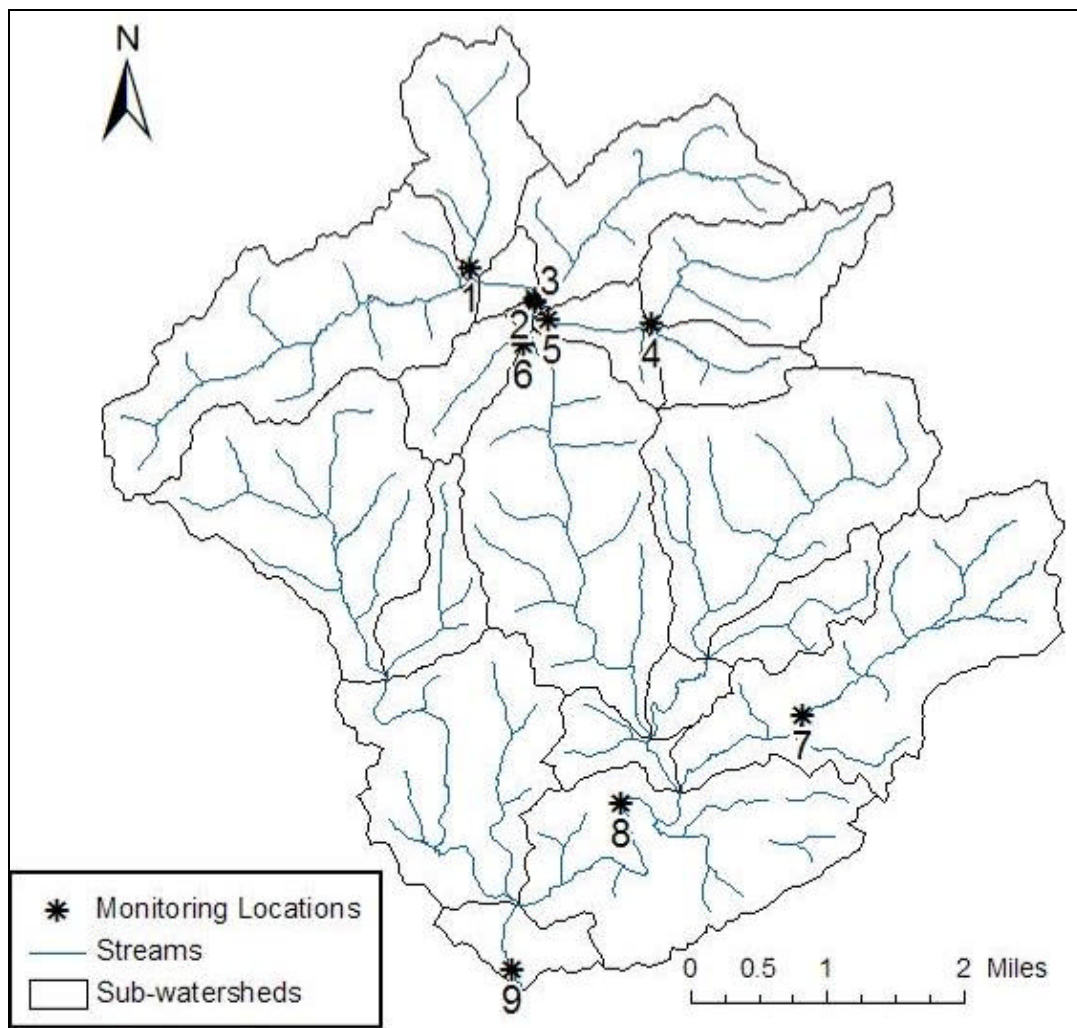
## Validation with Lick Creek Data

Flow rates were recorded at several locations in Lick Creek during the simulation period (Table 6, Figure 9).

**Table 6. Stations with recorded flow data and count of observations.**

Station Name	Count	Map Location Number in Figure 9
Cigarette Hollow Branch at Route 63, at Dante, Va.	3	4
Gravel Lick Creek at School STP, nr Hamlin, Va.	3	7
Laurel Branch at Dante, Va.	3	1
Straight Hollow Branch at Route 608, at Dante, Va.	3	3
Right Fork at Mouth, at Dante, Va.	3	5
Left Fork at Route 627, at Dante, Va.	3	2
Lick Creek at Route 608, at Dante, Va.	3	6
Lick Creek at Hamlin, Va.	11	8
Lick Creek at Route 628, at St Paul, Va. <sup>†</sup>	2	9

<sup>†</sup>More data were collected at this station, but they were collected prior to the start of the continuous weather record from the Wise 3E station and thus flows could not be simulated for those dates for comparison.



**Figure 9. Lick Creek Flow Monitoring Locations (numbers correspond to Table 6).**

There were insufficient flow data to conduct a complete calibration using observed flows from Lick Creek. Therefore, the calibrated parameters from Cranes Nest River (Table 5) were applied to the corresponding land uses in the Lick Creek watershed. It is important to check to make sure that the model simulations made using these parameters produce results that are reasonable for the Lick Creek watershed. For instance, if the model predicted flow rates an order of magnitude greater or less than the observed flows on the observed flow dates, the parameters would not have been appropriate for use in Lick Creek. To ensure that the model parameters calibrated for the Cranes Nest River watershed were appropriate for the Lick Creek watershed, observed flows at each monitoring location (Figure 9) were compared to simulated flows at the corresponding sub-watershed outlets. The results are shown in the remaining figures in this document. As can be seen from the figures, the simulated flows match the few observed points well. Thus, the calibrated parameters are acceptable for use in the Lick Creek watershed.

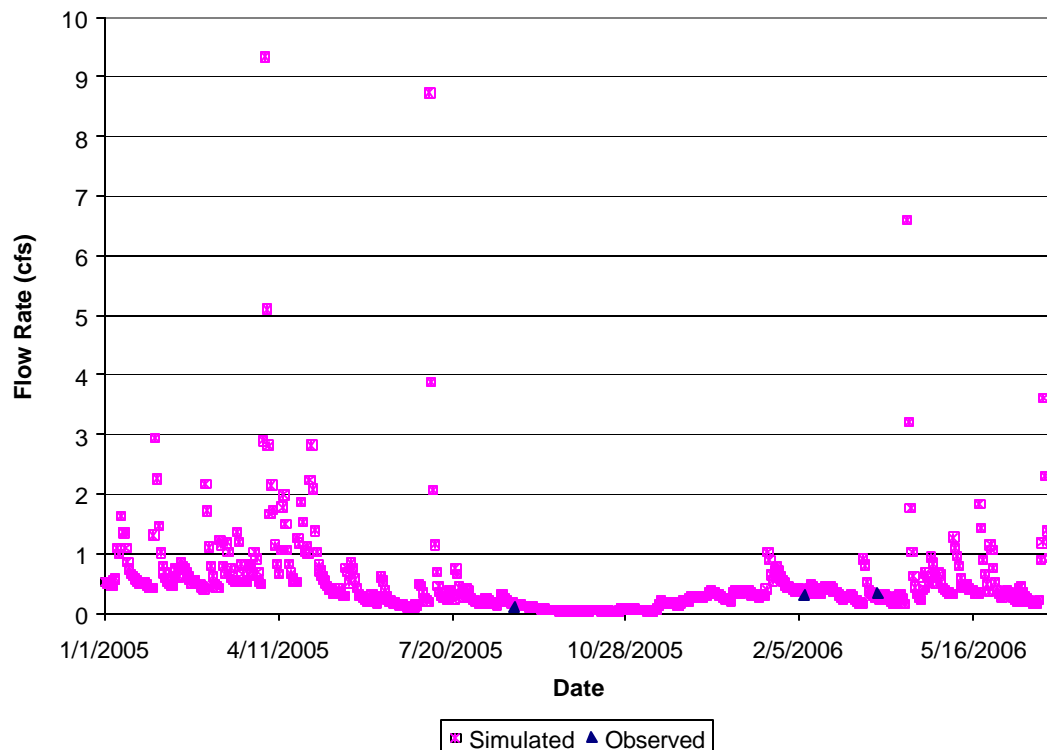


Figure 10. Observed and simulated flows at Cigarette Hollow (map location 4).

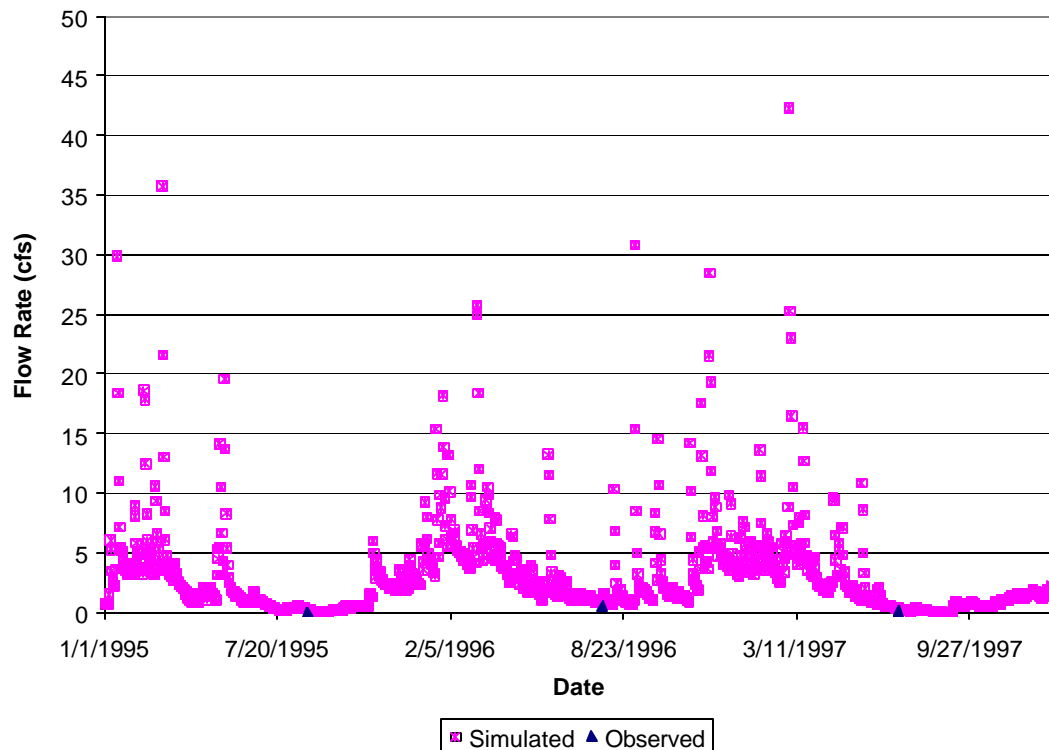


Figure 11. Observed and simulated flows at Gravel Lick Creek (map location 7).

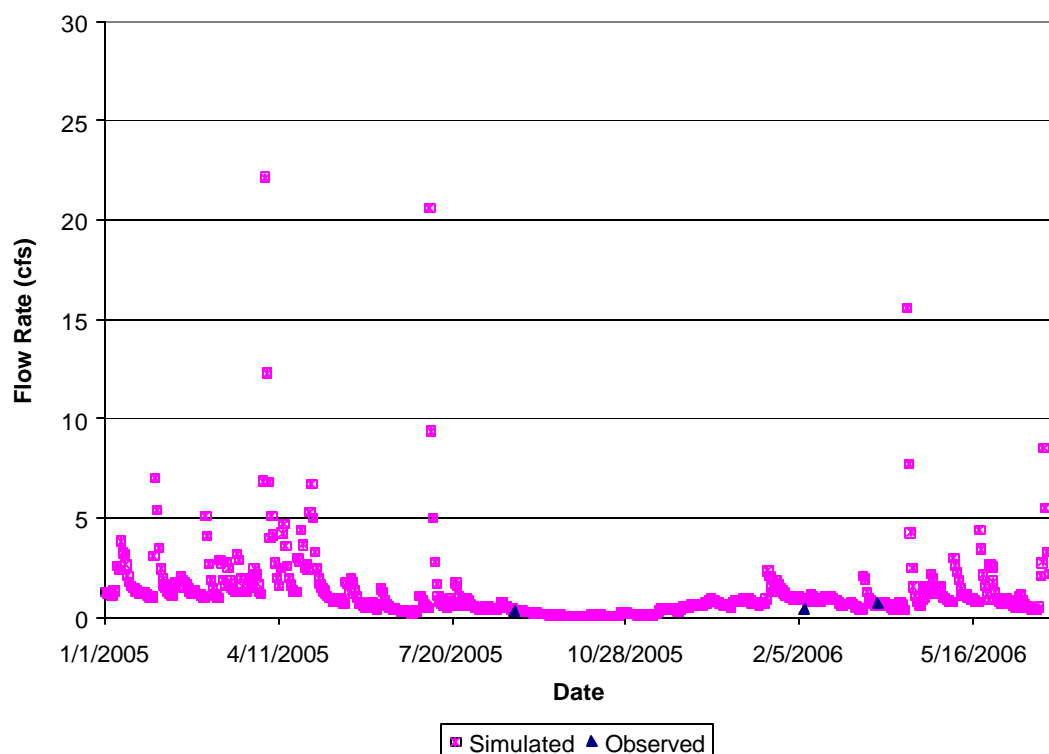


Figure 12. Observed and simulated flows at Laurel Branch (map location 1).

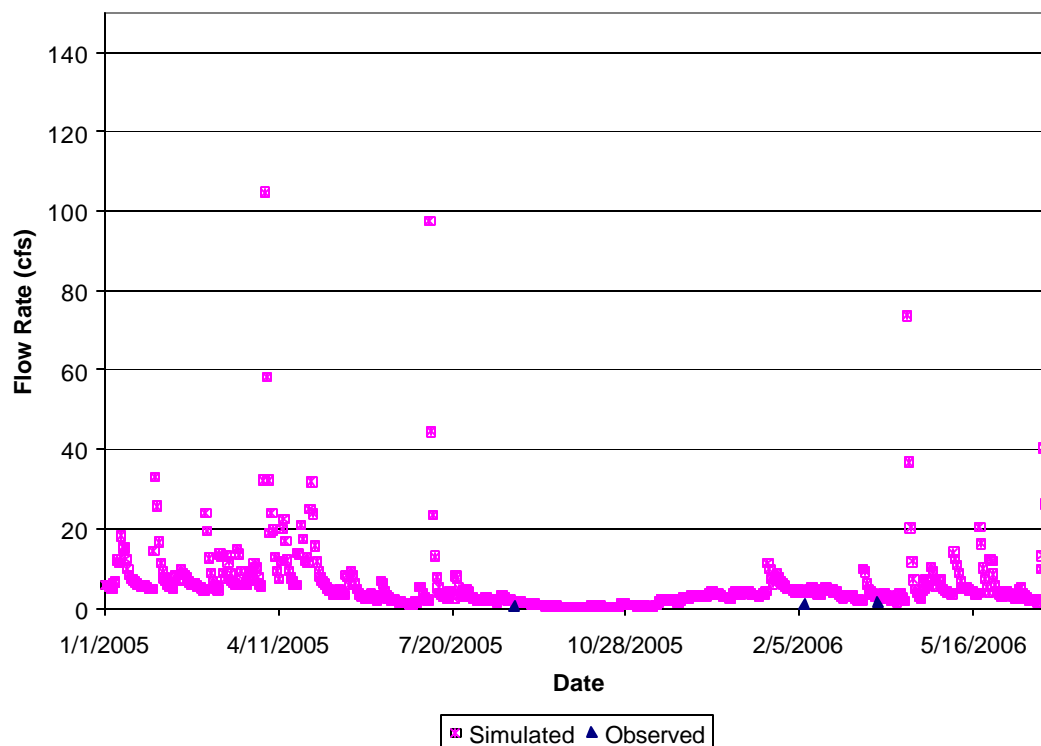


Figure 13. Observed and simulated flows at Straight Hollow (map location 3).

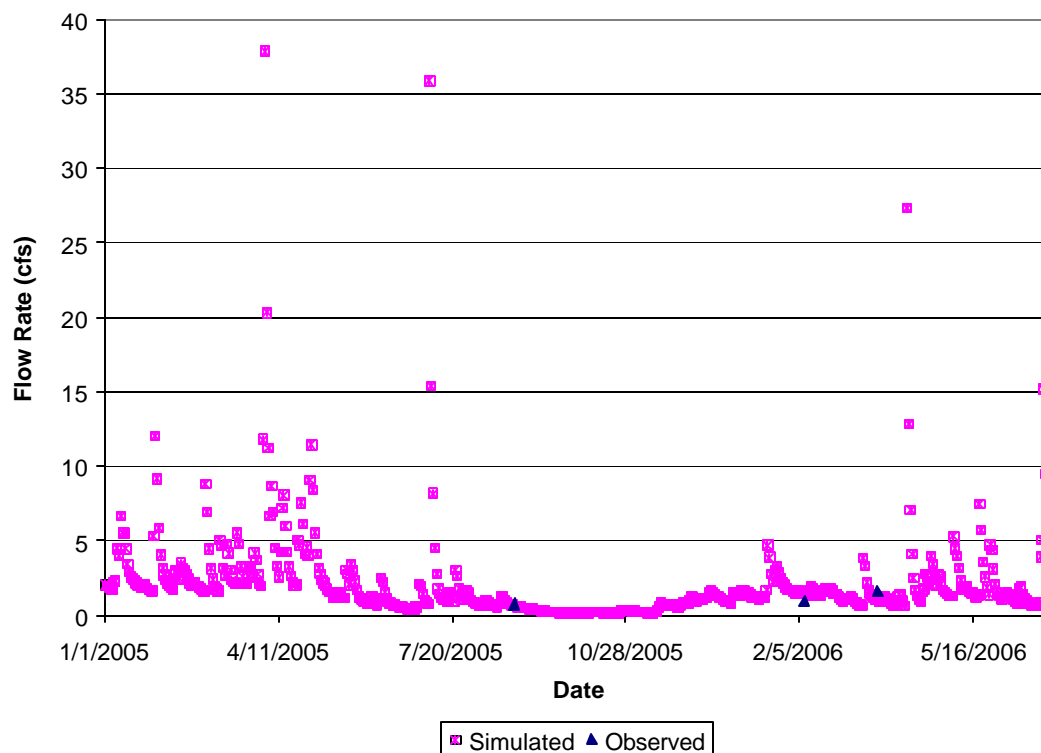


Figure 14. Observed and simulated flows at Right Fork (map location 5).

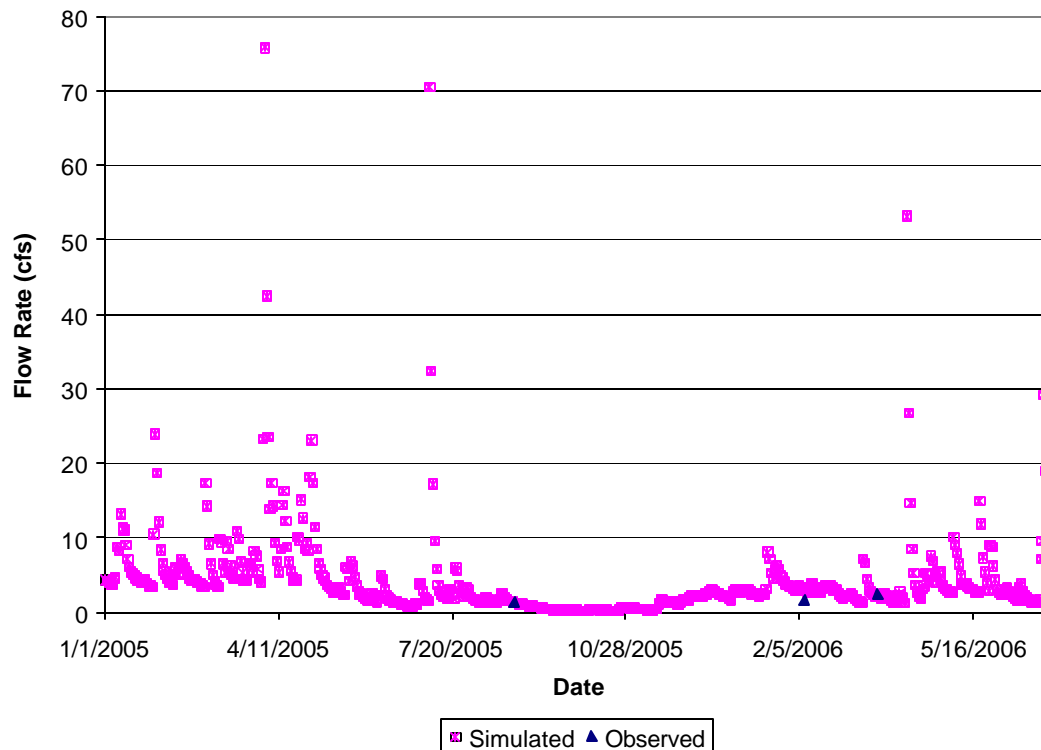


Figure 15. Observed and simulated flows at Left Fork (map location 2).

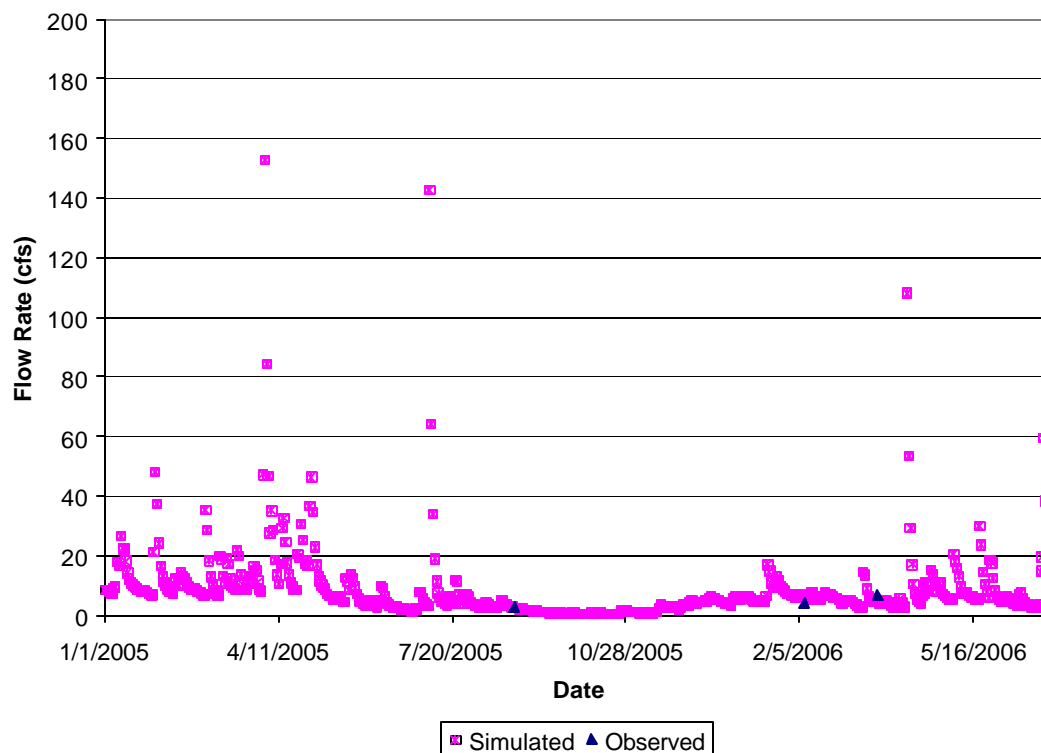


Figure 16. Observed and simulated flows at Lick Creek at Rt 608 (map location 6).

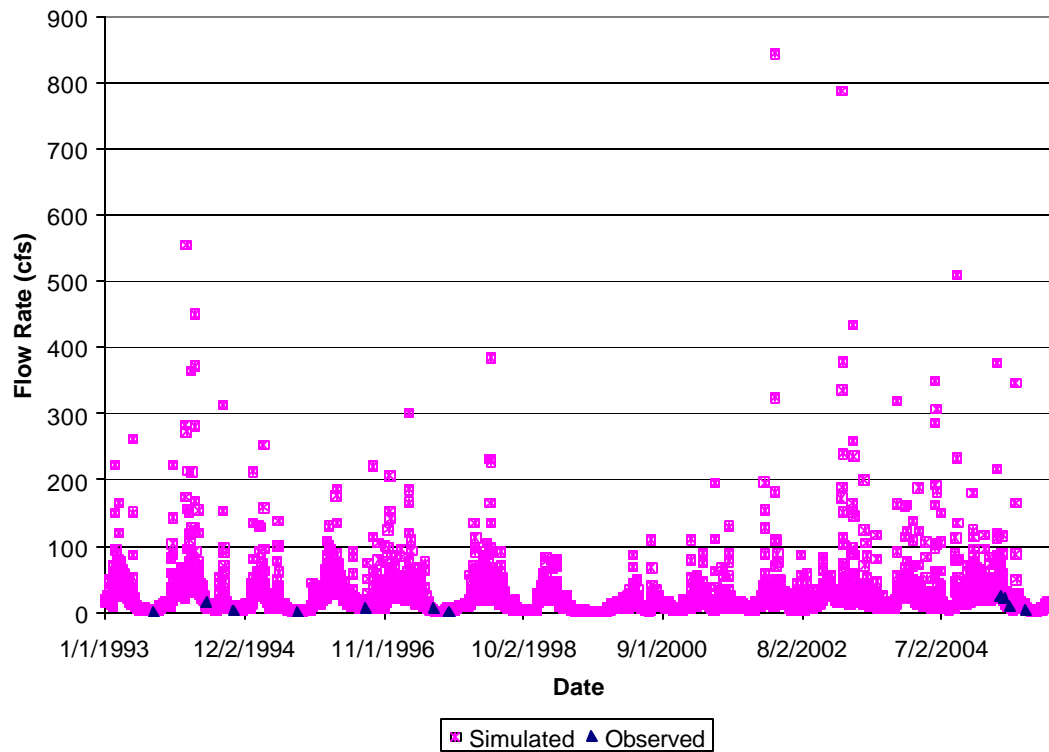


Figure 17. Observed and simulated flows at Lick Creek at Hamlin (map location 8).

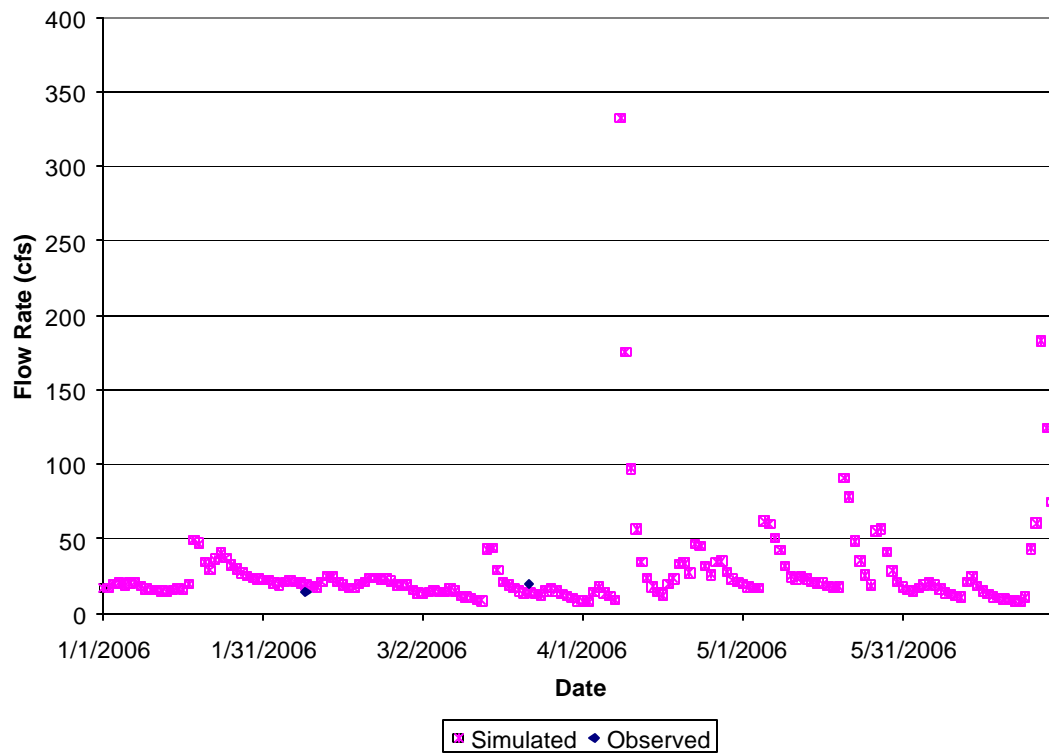


Figure 18. Observed and simulated flows at Lick Creek at Rt. 628 (map location 9).

# **Appendix**

**Table 7. PWAT-PARM2 parameters varying by land use.**

Land Use	INFILT (in/hr)	LSUR (ft)	SLSUR (ft/ft)
Forest	0.284	100	0.3111
Pasture	0.252	100	0.2736
Cropland	0.286	164	0.1666
High Density Residential	0.186	50	0.2199
Low Density Residential	0.186	199	0.1500
Extractive	0.186	100	0.2903

**Table 8. MON-INTERCEP (monthly CEPSC) - Monthly Interception Storage.**

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Forest	0.1	0.1	0.13	0.16	0.2	0.32	0.32	0.32	0.2	0.14	0.12	0.1
HDR	0.09	0.09	0.09	0.09	0.09	0.11	0.11	0.11	0.09	0.09	0.09	0.09
LDR	0.09	0.09	0.09	0.09	0.09	0.11	0.11	0.11	0.09	0.09	0.09	0.09
Pasture	0.08	0.09	0.13	0.16	0.18	0.2	0.2	0.2	0.19	0.14	0.1	0.08
Crop	0.06	0.07	0.1	0.18	0.21	0.26	0.26	0.23	0.2	0.18	0.08	0.06
Extractive	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.02	0.02	0.02	0.02

**Table 9. MON-LZETP - Monthly Lower Zone Evapotranspiration Parameter.**

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Forest	0.35	0.35	0.45	0.5	0.55	0.75	0.75	0.65	0.6	0.5	0.45	0.35
HDR	0.25	0.25	0.27	0.27	0.3	0.3	0.3	0.3	0.27	0.27	0.25	0.25
LDR	0.25	0.25	0.3	0.3	0.35	0.35	0.35	0.3	0.3	0.3	0.25	0.25
Pasture	0.25	0.35	0.45	0.5	0.55	0.75	0.75	0.65	0.6	0.5	0.4	0.25
Crop	0.25	0.35	0.45	0.5	0.55	0.75	0.75	0.65	0.6	0.5	0.4	0.25
Extractive	0.1	0.1	0.1	0.1	0.15	0.15	0.2	0.2	0.2	0.15	0.1	0.1